2967

Safe Milk in the Atomic Age

WILBUR I. PATTERSON

In 1959, testing of nuclear weapons had created worldwide fear of the dangers to health from radioactive fallout. Some governments urged their scientists to find ways to eliminate fallout from foods. Frightened citizens added their voices to the clamor.

Scientists developed first a laboratory technique to remove radioactive fallout from milk. This technique with the aid of milk technology and engineering knowledge was converted to a successful commercial scale process.

In the United States, three agencies had responsibilities connected with fallout. The Atomic Energy Commission controls the use of radioactive materials in the United States. Several agencies of the Department of Health, Education, and Welfare have duties to protect people from foods which may contain hazardous substances. And the U.S. Department of Agriculture is responsible for food production, including the processing of food into a safe form for eating.

The element considered most dangerous in food contaminated with fallout is radioactive strontium, which acts like calcium in the body and therefore seeks the bones. The radioactivity is a potential cause of cancer.

Radiostrontium persists for a long time; after 28 years only half of it has changed to a harmless state.

Radioactive iodine is also formed in nuclear explosions. Since half of its radioactivity is lost every 8 days, its danger exists for a much shorter time than the strontium hazard. Only 3 percent of radioactive iodine is left after 40 days.

However, iodine concentrates in the thyroid gland, and the radioactive kind could damage this organ or possibly cause cancer here, too. So, any treatment to make food contaminated with nuclear fallout safe should remove both strontium and iodine.

A nuclear accident in Great Britain in 1957, with resultant contamination of pastures and milk, necessitated the discarding of milk from a 30-square mile area.

Sam R. Hoover of the Agricultural Research Service initiated experiments in USDA to remove radionuclides from milk.

Other laboratories had already experimented with ion exchange treatments of milk to remove radioactive elements. B. B. Migicovsky at the Canadian Government laboratories in Ottawa first demonstrated in the laboratory the principle of removing radioactivity from milk with ion exchangers in a way designed to preserve its normal mineral composition, taste, and appearance. Later, the procedure was refined and adapted to commercial scale milk processing.

Since three Government agencies had responsibilities for protecting the Nation's food supply against radioactive fallout, a cooperative attack on the problem was arranged. Each agency agreed to contribute an equal share of the cost. USDA furnished laboratory and pilot plant space and, most valuable of all, experts in milk technology. The Public Health Service carried out chemical tests and sanitation studies on the process at its Robert A. Taft Sanitary Engineering Center in Cincinnati and assigned scientists to USDA's Research Center at Beltsville, Md. PHS scientists also supervised nutritional studies on treated milk to make sure that the treatment had not changed the nutritional value in any way, either through adding harmful substances or removing any essential component, as a vitamin.

By ordinary standards of measuring impurities, the amount of the radiostrontium ever to be expected in contaminated milk is infinitesimally small. The allowable dosage of radiation is related to the amount and type or power of the radiation. One guideline given by the Federal Radiation Council is 200 picocuries of strontium-90 per day; this daily intake of radiation for life is not believed to present any hazard at all. Two hundred picocuries of strontium-90 is equivalent to approximately one million-millionth of a gram, an amount invisible to the eye.

Compared to the radiation we all receive from natural sources such as cosmic rays or the traces of radioactive elements in rocks, the radiation from fallout in foods is small indeed. It is also small compared to the radiation we receive from X-rays of our teeth and other medical treatments.

Finding such minuscule amounts of an impurity in any material as complex as milk may not seem possible, but analytical techniques based on radioactivity are extremely sensitive. To remove these relatively few molecules from a quart of milk may sound absurd. However, background information on the removal of radionuclides from water to make it safe was available. This was an already technically feasible process based on ion-exchange techniques. In similar laboratory tests on milk to which radiostrontium had been added, variable percentages of strontium-90 were removed, usually less than 80 percent.

The calcium in fresh milk is bound to the milk proteins. When milk sours, the calcium is set free. Experiments in

WILBUR I. PATTERSON *is Assistant Director for Program Development, Eastern Utilization Research and Development Division, Agricultural Research Service.*

the Public Health Service laboratories showed that in slightly sour milk more than 90 percent of radiostrontium is removed from milk by a selected commercial cation exchanger. Charging the exchanger with the right proportion of calcium, magnesium, potassium, and sodium chlorides permitted the removal of more than 90 percent radiostrontium without changing the concentration of those elements. Scientists of the PHS and ARS received a public service patent on the process, thus assuring the public of free use of it.

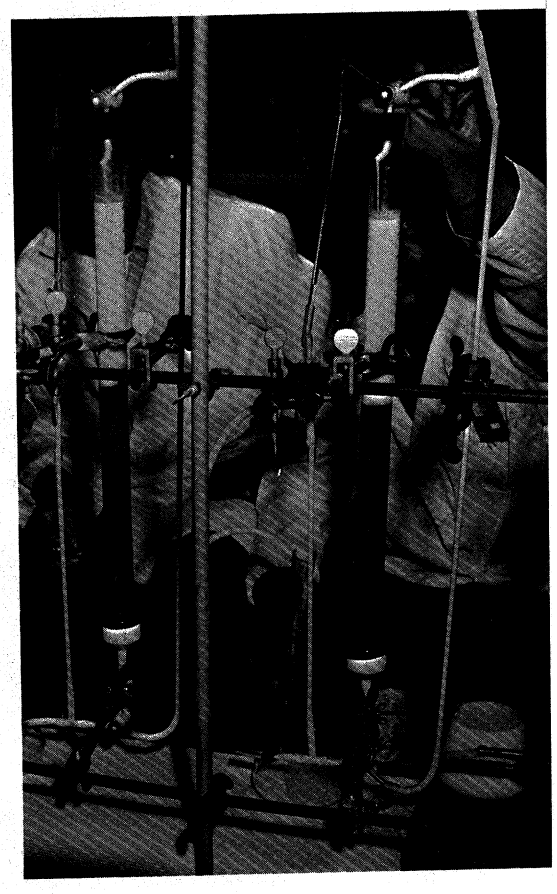
Yet another problem was created by making the milk slightly sour; if the milk is too sour, the protein will coagulate. This was avoided by the carefully controlled addition of citric acid solution in the right amount. Milk normally contains a little citric acid.

The treatment must produce no appreciable change in flavor. So the sour taste had to be removed by adding a little potash, also a normal constituent of milk. The average consumer cannot taste any difference between the treated and untreated milk.

With a satisfactory laboratory process worked out, a pilot plant was the next step. Automation is desirable in modern food processing. Thus, the pilot plant design included automatic controls and it had a capacity of 100 gallons per hour.

No process can be called commercially successful until actual test on a commercial scale. Knowledge gained from the pilot plant experience permitted design of a commercial scale plant. This meant conversion of the original experiment with ounces of milk through a pilot plant to the commercial scale in which 100,000 pounds of milk were processed in an 8-hour day. The increase in size was accompanied by a host of technical problems not fully realized even on the pilot scale. One of the many problems in such a large scale test was location and cost. Only a few geographical areas could supply the needed milk since their production is geared for normal requirements.

Since this removal process did not have official clearance to permit use of the treated milk for human consumption, the milk was dried and then used in animal feed.

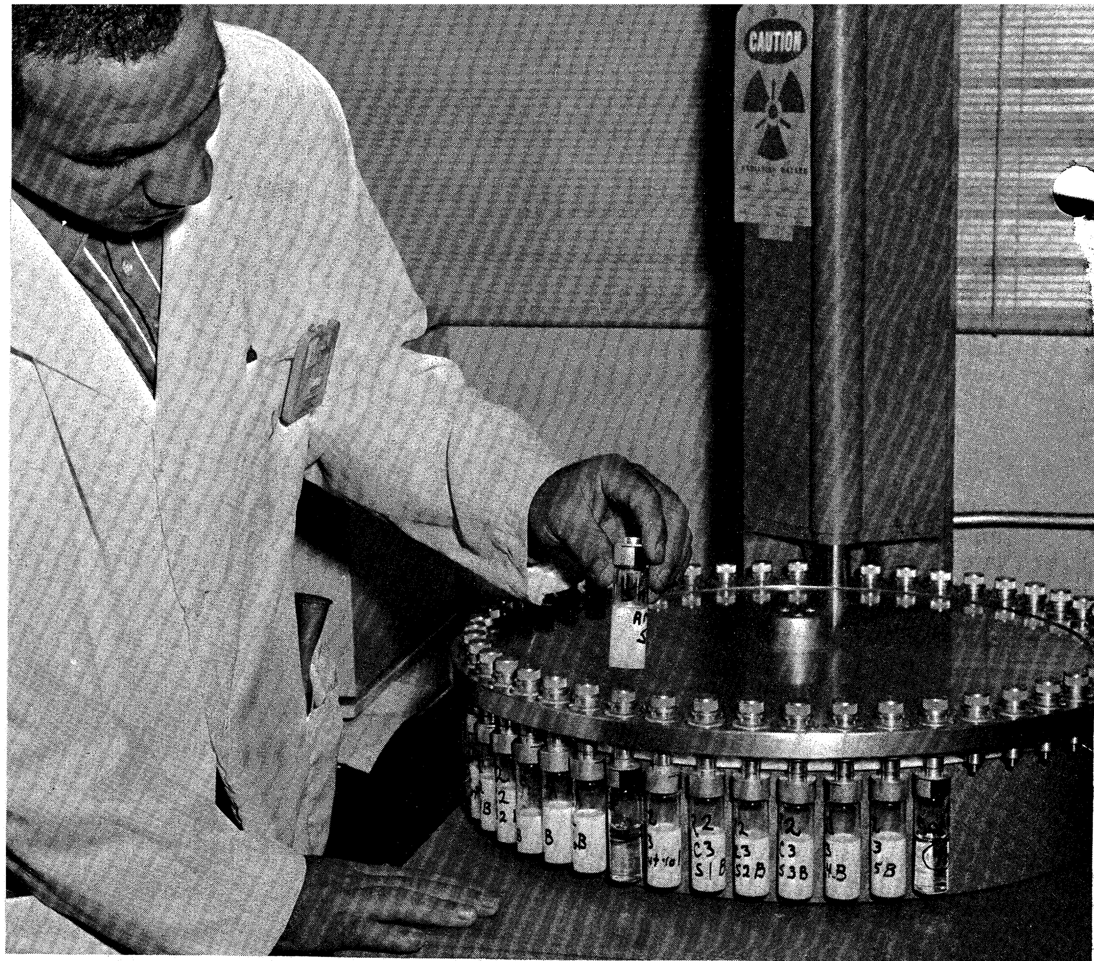


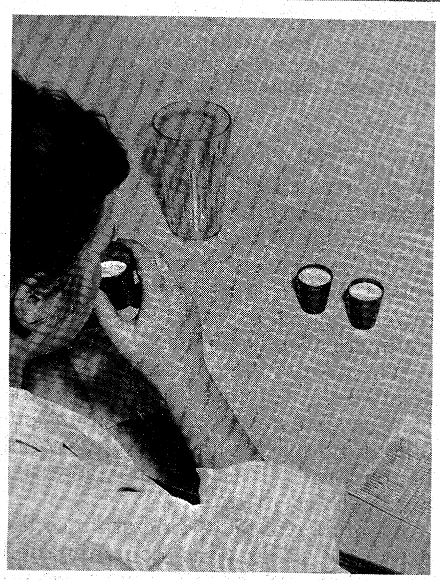
Laboratory tests being made with small columns of ion exchange resin to determine effectiveness of process in removing radioactive elements from milk.

Such large tests were considered essential before the process could be recommended as suitable for use in commercial milk plants.

When to use the removal process has resulted in lengthy discussions. One view is that any contamination from fallout, no matter how minute, should be removed. This extreme view has not been accepted.

A number of factors determines the extent of radioactive contamination allowed in milk before removal would





Processed milk samples being tested for radiostrontium contamination with a scintillation counter, *above.* Jesse Harris, Public Health Service officer, loads the counter which handles 50 samples at one time. Trained taster, *left,* checks for any flavor changes in milk that has been put through all of the steps to remove radio-strontium.

be recommended. The Federal Radiation Council was set up to establish levels of radiation in food above which removal might be necessary.

Besides giving efficient removal of radionuclides, the process must not change to any significant degree the composition of milk or its nutritive value or cause bacterial contamination. The acidification and neutralization steps do increase the citrate and potassium contents of the treated milk; but these changes are considered unimportant.

Extensive feeding tests with rats and pigs showed no difference in nutritive values between the treated and untreated milk. Conditions were devised to control bacterial contamination.

If practical ways could be found to keep radioactivity out of milk so its removal would not be necessary, this would be preferable to removal. Since most radioactivity in milk obviously comes from the cow's diet (very little comes from air), feeding a diet free of fallout radioactivity would solve the problem. But removing the fallout from pasturage and other feeds, at the moment at least, is far more difficult than removal from milk itself, with one exception: Iodine-131 has a half life of 8 days. Thus, storage of contaminated hay and feed for 40 days before feeding the cow should result in milk with safe levels of iodine-131. With the long-lived radioisotopes, like strontium-90, feed storage has no appreciable value in reducing milk contamination. The cow secretes only one-fifth to one-tenth of the ingested strontium-90 into her milk.

Another version of the storage method of avoiding iodine-131 consumption in milk is through processing milk into a sterile product or into dry milk (preferably nonfat milk which can be recombined later with the milk fat). Such a procedure would increase cost.

Although the ion-exchange process is semicontinuous, today's trend to completely automated and continuous processing prompted further engineering research on equipment design. Again, there was already available for other purposes ion-exchange equipment with automatic cycling. On a pilot scale (10 gallons per hour), this apparatus was successfully used to remove radionuclides from milk. However, certain problems—especially sanitary design of some parts—still have to be resolved for commercial size equipment.

For a temporary emergency, cost may not be critical. But if treatment over an extended time should ever be required, cost becomes extremely important. To remove both radiostrontium and iodine, the cost for the commercial test was about 6 cents per quart. The actual cost will depend upon the quality of chemicals used in regenerating the ion exchanger. This cost is believed to be acceptable in an emergency. For the removal of only strontium-90, the cost is about 2 cents per quart.

Development of this process from laboratory to commercial scale cost the government somewhat more than $1 million. The annual value of milk on the farm is about $5 billion.

In 1962, when fallout from testing nuclear weapons was at its highest, the iodine-131 content reached a level in a few areas which prompted Government officials to recommend the use of stored feed (free of radioactivity) for dairy cows. This was continued only for a few weeks until the radioiodine had changed into substances with no radioactivity.

So far, the level of radioactivity in milk has never reached a figure for which widespread removal has been recommended. If this time should ever come, the technical knowledge is available. Estimates of the time period which would be required to equip dairy plants vary from 6 months to a year. Research to date shows the job could be done should it ever be necessary. With the increasing proliferation of nuclear weapons despite international efforts to prevent their spread, the potential danger still exists. Further knowledge on removing radioactivity from food is important for the continued welfare of mankind.